I-06.01 Design Philosophy

The basic philosophy to consider when designing new or existing roadway facilities is to do so in accordance with AASHTO A Policy on Geometric Design of Highways and Streets, 4th edition, 2001; hereinafter referred to as *A POLICY*. In using *A POLICY*, generally start with the minimum values provided and then adjust them as the need would dictate. There may be circumstances where it may be in the best interest to use the minimum or desirable values. There may be circumstances where it may not be in the best interest to use the values in *A POLICY*. In those instances, it would be necessary to develop different values and process a design exception. Design exceptions are defined in more detail in Section I-06.04 of the Design Manual.

The philosophy to consider when applying *A POLICY* design values is to do so in accordance with NDDOT DESIGN GUIDELINES for Preventive Maintenance, Minor Rehabilitation, Structural Improvement, Major Rehabilitation, and New/Reconstruction Projects, March 2007; hereinafter referred to as *DESIGN GUIDELINES*. The *DESIGN GUIDELINES* are FHWA approved and recognized as of March 19, 2007. The *DESIGN GUIDELINES* have been incorporated into the Design Manual and are found in Section I-06.03 of the Design Manual. A link to Section I-06.03 of the Design Manual can be found on the web at http://www.dot.nd.gov/manuals/design/designmanual/designmanual.htm

The Director may designate and post special areas of state highways where lower speeds are required by condition. The design speeds for those segments are to be determined during the Project Concept Report process.

Safety measures and issues will be identified and addressed as part of the Statewide Safety Program. The Statewide Safety programs will consist of four different types of analysis: Critical Rate Analysis, High Crash Analysis, Project Level Analysis, and Strategic Highway Safety Plan. Safety measures will be implemented with a safety project that will be scheduled and included in the Statewide Transportation Improvement Program (STIP), or if cost effective to be included with other projects. The Statewide Safety Program is defined in more detail in Section I-06.05 of the Design Manual.

I-06.02 Investment Strategies

The North Dakota Department of Transportation, NDDOT, in conjunction with the Federal Highway Administration, FHWA, has developed a series of investment strategies outlined in the *DESIGN GUIDELINES* that will ensure the life expectancy of the roadway is met. These investment strategies are Preventive Maintenance, Minor Rehabilitation, Structural Improvement, Major Rehabilitation, and New/Reconstruction Projects. Below is a brief summary of each investment strategy:

Preventive Maintenance – The intended purpose of this strategy is to protect the pavement structure, slow the rate of pavement deterioration, and/or correct deficiencies in the pavement surface only; structural deficiencies cannot be corrected with this application. The surface defects may be caused by the environment, and by daily wear and tear of traffic. This type of project may occur on the same roadway as frequently as supported by a cost effectiveness determination. A detailed definition of Preventive Maintenance can found in Section I-06.03.01, which also includes examples of projects that can be considered Preventive Maintenance. An overlay is considered to be Preventive Maintenance when the maximum thickness is two inches (no allowance for rut filling).

Minor Rehabilitation – This strategy aims to correct the structural integrity of the pavement without necessarily changing the existing geometrics. A detailed definition of Minor Rehabilitation can be found in Section I-06.03.02, which also includes examples of projects that can be considered Minor Rehabilitation. When an overlay is between two and three inches the project is considered to be Minor Rehabilitation.

Structural Improvement – A Structural Improvement restores the structural integrity of the pavement without necessarily changing the existing geometrics. In addition, the load carrying capacity should be increased to meet the HPCS guidelines. A detailed definition of Structural Improvement can be found in Section I-06.03.03. A Structural Improvement is either an HBP overlay in excess of three inches or a white top.

Major Rehabilitation – Major Rehabilitation requires a large amount of work to bring the condition of the highway up to a level that will extend the service life. This strategy also provides the opportunity to perform operational improvements. A detailed definition of Major Rehabilitation can be found in Section I-06.03.04, which also includes examples of projects that can be considered Major Rehabilitation.

New/Reconstruction – There may be extensive changes to the existing route such as relocating on a new alignment, or completely removing the roadway down to the subgrade and rebuild from the bottom up. Everything from ADA requirements to signing must be addressed when performing a new or reconstruction project. A detailed definition of New/Reconstruction can be found in Section I-06.03.05.

I-06.03 Design Guidelines

1. The intent of the roadway width guidelines is not to reduce the roadway width to the minimum width shown in the guidelines, but rather to maintain the width as close as possible to the existing width.

2. If a District Corridor is on the NHS system the roadway will be designed to meet the minimum design guidelines for a State Corridor.

3. Design features that do not meet the minimum design guidelines, but are incorporated into a project will require a design exception.

4. Safe pavement sloughs will be maintained as described in the Departments shoulder/slough standards. If there is no shoulder the slough should have a minimum slough of 3:1.

5. The traffic volumes shown are general guidelines. A 10 % tolerance in the volumes may be allowed without requiring the designer to move to the next level of standard or the need for a design exception.

6. The rail system is defined as both the bridge and roadway facility rail systems servicing as one entire rail system including all of the following items:

   - end treatments and end terminals
   - linear guardrail runs
   - transition sections
   - bridge rails

   In cases where the roadway strategy and bridge strategy for the rail system are different, the investment strategy with the highest rail system requirement will be applied to the entire rail system.

   On Minor Rehabilitation and Structural Improvement roadway projects, the rail system may be left in place if the rail system was originally installed in conformity with NCHRP Report 230 or 350 crash test criteria or equivalent standard, and has been maintained in a condition that is in reasonably close conformity to NCHRP 230 or 350 guidelines or equivalent standard.

   The following is considered reasonably close conformity for the linear runs portion of the rail system:

   - Variation for height of rail is ± 3 inches of the design dimension when originally installed.

   - No un-repaired damage to the linear run is visible and there is evidence of adequate maintenance of key as-built elements including posts, block outs, rail elements and rail delineation.

   The following is considered reasonably close conformity for end treatments/terminals of the rail system:

- No un-repaired damage to the end treatment is visible and there is evidence of adequate maintenance of key as-built elements including posts, block outs, rail elements, tensioning devices, breakaway devices and end treatment delineation.

The following is considered reasonably close conformity for transition sections of the rail system:

- No un-repaired damage to the transition section is visible and there is evidence of adequate maintenance of key as-built elements including posts, block outs, rail elements, and connection to the fixed object.

In addition to being in reasonably close conformity to NCHRP Report 230 or 350 crash test guidelines or equivalent standard, the geometric layout and past performance of the rail system should meet the following criteria:

- Be functionally adequate for length of need, flare rate, slope, etc. based on the existing ADT and posted speed less 10 mph.

- Exhibit no significant crash history at the installation location.

Non-standard end treatments and/or transition sections may be removed and replaced without adjustment to the linear run segments if the linear run segments are in reasonably close conformity to the NCHRP Report 230 or 350 guidelines or equivalent standard.

I-06.03.01 Preventive Maintenance

Design Guidelines for Preventive Maintenance Projects

Traffic Data	Use current ADT
Roadway Width	Use appropriate width to meet NDDOT guidelines.
Superelevations	Use existing.
Design Speed	Use posted speed limit.
Driving Lane Cross Slope	Use Existing.
Horizontal Curvature	Use existing.
Vertical Curvature	Use existing.
Clear Zone	Use existing.
Inslope	Use existing
Roadway Shoulder/Slough Cross Slope	Use Department Shoulder Standards. (See appendix B)
Safety	Safety issues will be identified and addressed as part of the Statewide Safety Program. Safety features will remain as they exist unless a need is identified.

The purpose of the Preventive Maintenance program is to protect the pavement structure, slow the rate of pavement deterioration and/or correct pavement surface deficiencies. Surface treatments used for preventive maintenance are targeted at pavement surface defects primarily caused by the environment and by the daily wear and tear of traffic. Structural deficiencies caused by traffic loading are not corrected by using these treatments.

Preventive Maintenance treatments may be applied as frequently as supported by a cost effectiveness determination. Improvements for ADA requirements will be considered and be addressed in the environmental document. Most preventive maintenance projects will be conducted on the top of the existing roadway and will have no impact to wetlands or cultural resources. Miscellaneous features such as mailboxes, signing, delineators and others will not be required to be upgraded as part of these projects unless identified by the Statewide Safety Program. Signage not in compliance with the MUTCD will be updated if engineering judgment indicates that:

- One compliant device in the midst of a series of adjacent non-compliant devices could potentially be confusing to road user.
- The anticipated schedule for replacement of the whole series of non-compliant devices will result in achieving timely compliance with the MUTCD.

All railroad crossings will have adequate warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.

Examples of Preventive Maintenance treatments are: Crack Pouring/Sealing, Route and Seal, Seal Coats, Micro-Surfacing, Milling and Asphalt Overlay 2" Maximum (no allowance for rut filling), Asphalt Overlay 2" Maximum (no allowance for rut filling), Repair of depressed cracks, Minor Concrete Pavement Repair (less than 10% of the pavement surface area per mile), Dowel Bar Retrofit, Diamond Grinding, Pavement Marking, Painting Structures, etc.

I-06.03.02 Minor Rehabilitation

Design Guidelines for Minor Rehabilitation Projects

Traffic Data	Use current ADT
Roadway Width	Use appropriate width to meet NDDOT guidelines.
Superelevations	Use existing.
Design Speed	Use posted speed limit
Driving Lane Cross Slope	Use Existing.
Horizontal Curvature	Use existing.
Vertical Curvature	Use existing.
Clear Zone	Use existing.
Inslope	If the proposed inslope is less than 3:1 consider cost effective treatment. In fill sections where the inslope breaks to less than 3:1 outside the clear zone a 4:1 inslope should be used in the clear zone.
Roadway Shoulder/Slough Cross Slope	Use Department Shoulder Guidelines. (See appendix B)
Safety	Safety issues will be identified and addressed as part of the Statewide Safety Program. Safety features will remain as they exist unless a need is identified. Safety hardware that does not meet NCHRP 230 standards or better will be upgraded to meet NCHRP 350 standards.

Minor Rehabilitation is a planned strategy to extend the useful life of a highway by restoring the pavement structure without necessarily improving existing geometrics. The minor rehabilitation of roadways will use repair techniques designed to repair pavement distress areas primarily caused by the environment and by the daily wear and tear of traffic. A minor rehabilitation strategy will restore the load carrying capacity to its original condition. During the scoping process the department will determine if the inslope criteria is being met. The appropriate NEPA process will be followed to address any environmental impacts. Improvements for ADA requirements will be considered and be addressed in the environmental document. Miscellaneous features such as mailboxes, signing, delineators and others will not be required to be upgraded as part of these projects unless identified by the Statewide Safety Program. Signage not in compliance with the MUTCD will be updated if engineering judgment indicates that:

- One compliant device in the midst of a series of adjacent non-compliant devices could potentially be confusing to road user.
- The anticipated schedule for replacement of the whole series of non-compliant devices will result in achieving timely compliance with the MUTCD.

All railroad crossings will have adequate warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.

Examples of Minor Rehabilitation treatments are: Asphalt Overlay 2”-3”, Distress Area Repairs and Asphalt Overlay, Mill & Overlay 2”-3”, Cold In-Place Recycling (CIR), sliver grading to correct inslope or re-establish the original roadway, Bridge Approach Repair, Bridge Rail Repair, Deck Overlay, Guardrail, etc.

Sliver grading is defined as minor grading required to correct inslope, or re-establish enough roadway width to meet the NDDOT minimum design guidelines. Sliver grading is limited to 2’ maximum of widening on each side of the roadway. Sliver grading is not grading to add roadway width beyond the original roadway. Examples of sliver grading are shown in the Department Shoulder/Slough Guidelines.

I-06.03.03 Structural Improvements

Design Guidelines for Structural Improvements Projects

Traffic Data	Use 20 year projected
Roadway Width	Use appropriate width to meet NDDOT guidelines.
Superelevations	Attempt to correct to AASHTO Standards. (6% max superelevation, exhibit 3-22) Request design exception if not cost effective.
Design Speed	Use posted speed limit
Driving Lane Cross Slope	HBP Over Asphalt Roadways: 2.1% HBP Over Non Interstate Concrete Roadways: 1.5-2.5 % HBP Over Interstate Concrete Roadways: 1.5-2.5 %
Horizontal Curvature	Use existing, sign when less than posted speed.
Vertical Curvature	Use existing.
Clear Zone	20 foot clear zone.
Inslope	If the proposed inslope is less than 3:1 consider cost effective treatment. In fill sections where the inslope breaks to less than 3:1 outside the clear zone a 4:1 inslope should be used in the clear zone.
Roadway Slough	Use Department Guidelines for sloughs.
Roadway Shoulder Cross Slope	HBP Over Asphalt Roadways: 8.0 % Max. HBP Over Non Interstate Concrete Roadways: 8.0 % Max HBP Over Interstate Concrete Roadways: 6.0% Max
Safety	Safety issues will by identified and addressed as part of the Statewide Safety Program. Safety features will remain as they exist unless a need is identified. Safety hardware that does not meet NCHRP 230 standards or better will be upgraded to meet NCHRP 350 standards. Replace mailbox supports where necessary.

Structural improvement is a planned strategy to extend the useful life of a highway by restoring the pavement structure without necessarily improving existing geometrics. A structural improvement is a white topping project, crack and seat or break and seat and HBP overlay or an HBP overlay in excess of 3" and is designed based on an engineering analysis. A structural improvement will increase the load carrying capacity to meet the HPCS guidelines. The appropriate NEPA process will be followed to address any environmental impacts. Improvements for ADA requirements will be considered and be addressed in the environmental document. All regulatory and warning signs and pavement markings will be verified to comply with current MUTCD standards or brought up to MUTCD standards if necessary, and all railroad crossings will have adequate warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.

I-06.03.04 Major Rehabilitation

Design Guidelines for Major Rehabilitation Projects

Traffic Data	Use 20 year projected
Roadway Width	Use appropriate width to meet NDDOT guidelines.
Superelevations	Correct to AASHTO Standards. (6% max superelevation, exhibit 3-22)
Design Speed	Use posted speed limit.
Cross Slope	Driving lanes 1.5 – 2.5%, Shoulder 6% max.
Horizontal Curvature	Use existing, sign when less than posted speed. On State and Interregional Corridors with ADT >750, if existing horizontal curvature is designed for less than 15 mph less than the posted speed make cost effective improvement or sign accordingly.
Vertical Curvature	**Interregional System:** ADT < 2000 maintain existing. ADT > 2000 use stopping sight distance for crest curve design and comfort curve design for sag curves. Decision sight distance should be considered in areas where complex driver decisions are required such as intersections with major collectors or higher, interchanges, lane drops or additions, etc. Passing areas should be provided at reasonable intervals based on terrain and traffic volumes. A rule of thumb would be a passing area every 3 to 5 miles when the ADT <2000 and every 3 miles when the ADT >2000. **State Corridors, District Corridors & Collectors:** ADT < 2000, existing vertical curves should meet a design speed of no less than 20 mph below the overall project design speed. ADT > 2000 use stopping sight distance for crest curve design and comfort curve design for sag curves. Passing areas should be provided at reasonable intervals based on terrain and traffic volumes. A rule of thumb would be a passing area every 3 to 5 miles when the ADT <2000 and every 3 miles when the ADT >2000.
Clear Zone	Upgrade safety work to 20' clear zone except when ADT >2000 use AASHTO roadside design clear zone.
Inslope	4:1 minimum, on Interregional system > 2000 ADT a 6:1 inslope is desirable where grading or roadway widening is required.
Pavement Slough	Use NDDOT shoulder treatment methods.
Safety	A 90-1 survey will be completed and areas needing safety improvements will be addressed. Upgrade safety hardware to meet NCHRP 350 standards.

Major Rehabilitation is a planned strategy in which major work is performed to bring a highway up to an acceptable condition to extend the service life and provide operational improvements (i.e. adding turn lanes). Improvements for ADA requirements will be addressed in the environmental document.

Major rehabilitation projects may include reclaiming the existing surface material and base along with the placement of additional surface material and/or other work necessary to return an existing roadway, including shoulders, bridges, the roadside, and appurtenances to a condition of structural or functional adequacy. On these projects the roadway elevation may change, shoulders may be added, and foreslope corrections may be made. The roadway will be resurfaced and safety improvements will be completed as required. A crash analysis will be completed and cost effective enhancements will be addressed. All regulatory and warning signs and pavement markings will be verified to comply with current MUTCD standards or brought up to MUTCD standards if necessary, and all railroad crossings will have adequate

warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.

Examples of Major Rehabilitation treatments are: Mine and Blend and HBP, Full depth Reclamation, Major Concrete Pavement Repair (greater than 10% of the surface area per mile), etc.

I-06.03.05 New/Reconstruction Projects

Design Guidelines for New/Reconstruction Projects

Traffic Data	Use 20 year projected
Roadway Width	Use AASHTO Standards.
Superelevations	Use AASHTO Standards. (6% max superelevation, exhibit 3-22)
Design Speed	Use posted speed limit.
Cross Slope	Driving lanes 1.5 – 2.5%, Shoulder 6% max.
Horizontal Curvature	Use AASHTO Standards.
Vertical Curvature	**Interregional System:** Use stopping sight distance for crest curve design and comfort curve design for sag curves. Decision sight distance should be considered in areas where complex driver decisions are required such as intersections with major collectors or higher, interchanges, lane drops or additions, etc. Passing areas should be provided at reasonable intervals based on terrain and traffic volumes. A rule of thumb would be a passing area every 3 to 5 miles when the ADT <2000 and every 3 miles when the ADT >2000. **State Corridors, District Corridors & Collectors:** Use stopping sight distance for crest curve design and comfort curve design for sag curves. Passing areas should be provided at reasonable intervals based on terrain and traffic volumes. A rule of thumb would be a passing area every 3 to 5 miles when the ADT <2000 and every 3 miles when the ADT >2000.
Clear Zone	Use AASHTO roadside design clear zone.
Inslope	Use 4:1 except Interregional system > 2000 ADT and Interstate use 6:1
Pavement Slough	Use AASHTO Standards.
Safety	Safety hardware to meet NCHRP 350 standards.

Is defined as a planned strategy in which a new road is constructed. This work may include work items such as relocating an existing route on new alignment, or completely removing the old pavement structure and restoring the roadbed and surfacing, or major widening on an existing roadway to increase traffic capacity (excludes realigning horizontal curves).

On New/Reconstruction projects a crash analysis will be completed and cost effective enhancements will be addressed. All safety hardware will meet NCHRP 350 standards. ADA requirements will be addressed. All regulatory and warning signs and pavement markings will be verified to comply with current MUTCD standards or brought up to MUTCD standards if necessary, and all railroad crossings will have adequate warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.

I-06.03.06 Minimum Roadway Width on Four Lane Highways

Minimum Roadway Width on Four Lane Highways

Interstate 4 - Lane	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS
Major Rehabilitation	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS
Structural Improvement	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing
Minor Rehabilitation	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing
PM	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing

Interregional 4 - Lane	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS
Major Rehabilitation	36	36	36	36	36
Structural Improvement	32	32	32	32	32
Minor Rehabilitation	32	32	32	32	32
PM	31	31	31	31	31

I-06.03.07 Minimum Roadway Width on Two Lane Highways

Minimum Roadway Width on Two Lane Two Way Highways

Interregional 2 - Lane	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	32	36	36	36	40
Major Rehabilitation	30	30	36	36	36
Structural Improvement	26	26	28	30	32
Minor Rehabilitation	26	26	28	30	32
PM	26	26	28	28	30

State Corridor	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	32	36	36	36	40
Major Rehabilitation	*28	*28	*32	36	36
Structural Improvement	24	24	28	28	32
Minor Rehabilitation	24	24	26	28	32
PM	24	24	26	26	28

District Corridor	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	32	36	36	36	40
Major Rehabilitation	*26	*28	*30	32	36
Structural Improvement	22	24	26	26	28
Minor Rehabilitation	22	24	26	26	28
PM	22	24	24	26	26

District Collector	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	32	36	36	36	40
Major Rehabilitation	*26	*26	*28	30	30
Structural Improvement	22	22	24	26	26
Minor Rehabilitation	22	22	24	26	26
PM	22	22	24	26	26

- The intent of these guidelines is not to reduce the roadway width to the minimum guidelines, but rather to maintain the width as close as possible to the existing width. Roadway widths shown are the minimum recommended widths, actual allowable widths should be determined on a case by case basis using the Resurfacing Safety Resource Allocation Program (RSRAP) provided in NCHRP Report 486. If the width of the existing roadway is less than the stated guidelines, the width of the existing roadway may remain if it is determined to be safe by RSRAP and a design exception is approved.
- A design exception is only needed on a Preventive Maintenance Thin Lift Overlay (TLO) that does not meet the minimum roadway width requirement. All other Preventive Maintenance types of work do not require a design exception for minimum roadway width.
- District Corridor routes on the National Highway System (NHS) will be designed to State Corridor Guidelines
- Numbers in the shaded areas are ADT. Roadway widths are in feet.

* Minimum roadway widths for “Major Rehabilitation” strategies will be the same as “Minor Rehabilitation” strategies, unless widening is required. If widening is required to meet “Minor Rehabilitation” strategies minimum widths, widening will be sufficient to meet “Major Rehabilitation” strategies minimum widths.

I-06.03.08 Minimum Interstate and Four Lane Divided Highway Bridge Widths

Interstate & Four Lane Divided Highway	All ADT
*New or Reconstructed	40'
*Rehabilitation	Approach Roadway Width
Preventive Maintenance	Existing Bridge Width

* This bridge width is for a two lane roadway. Bridge widths will be determined on an individual bases, where there are 3 lanes or more, ramps or auxiliary lanes impacting the bridge.

The bridge widths in the above table are dimensions measured from face-to-face of curb or face-to-face of rail whichever is less.

The minimum bridge width shall be as shown in the table or the approach roadway width (traveled lanes plus shoulders), whichever is greater.

Deck replacements are in the Reconstructed category. Deck overlays are in the Rehabilitation category.

Any new or reconstructed two lane bridge over railroad tracks shall be a minimum of 40’ wide.

For Interstate System bridges longer than 200’, the traveled lanes plus 4’ on each side is an acceptable bridge width when considering new or reconstruction.

In assessing acceptable Interstate System bridge widths for rehabilitation of bridges or bridges to remain in place without rehabilitation within the limits of paving or re-grading projects: 1) bridges longer than 200’, that are as wide as the traveled lanes plus 3.5’ on each side are acceptable, 2) bridges shorter than 200’, that are as wide as the table less 4’ are acceptable; if there are no reported crash problems at that site.

For other four lane divided rural bridges longer than 200’, the traveled lanes plus 4’ on each side is an acceptable bridge width when considering new or reconstruction.

In assessing other four lane rural divided bridge widths for rehabilitation of bridges or bridges to remain in place without rehabilitation within the limits of paving or regarding projects: 1) bridges longer than 200’, that are as wide as the traveled lanes plus 2’ on each side are acceptable, 2) bridges shorter than 200’, that are as wide as the table less 4’ are acceptable; if there are no reported crash problems at that site.

For new or reconstruction projects, the rail system shall meet NCHRP 350 Test Level 3 or equivalent standard. For rehabilitation projects, all elements of the rail system can remain in place if the system meets or exceeds NCHRP 230 or an equivalent standard. If any part of the rail system does not meet or exceed NCHRP 230 or an equivalent standard, it will be upgraded to meet or exceed NCHRP 350 Test Level 3 or equivalent standard crash test criteria. For preventive maintenance projects, the existing railing system can remain.

Slope Protection repair, joint repair, painting, scour repair, abutment repair, pier repair, damaged railing repair, etc. are all examples of bridge preventive maintenance. For these types of preventive maintenance projects, the existing railing system can remain.

I-06.03.09 Minimum State Route Bridge Widths

Interregional 2 Lane	< 400**	400-750**	750-1500**	1500-2000**	> 2000**
New or Reconstructed	32'	36'	36'	36'	40'
Rehabilitation	28'	30'	30'	32'	32'
Preventive Maintenance	Existing Bridge Width				

State Corridor	< 400*	400-750*	750-1500*	1500-2000**	> 2000**
New or Reconstructed	32'	36'	36'	36'	40'
Rehabilitation	28'	30'	30'	32’	32'
Preventive Maintenance	Existing Bridge Width				

District Corridor	< 400*	400-750*	750-1500*	1500-2000**	> 2000**
New or Reconstructed	32'	36'	36'	36'	40'
Rehabilitation	28'	30'	30'	32'	32'
Preventive Maintenance	Existing Bridge Width				

District Collector	< 400*	400-750*	750-1500*	1500-2000**	> 2000**
New or Reconstructed	32'	36'	36'	36'	40'
Rehabilitation	28'	30'	30'	32'	32'
Preventive Maintenance	Existing Bridge Width				

* Existing bridge widths can remain if there is no crash history.

** For rehabilitation strategies or for bridges to remain in place within paving or re-grading projects, bridge widths are acceptable if the following criteria are met and there is no crash history

1. The existing width is no more than 4’ less than shown in the table; and,
2. The existing width is no more than 6’ less than the approach roadway.

All bridge widths in the above table are dimensions measured from face-to-face of curb or face-to-face of rail whichever is less.

Deck replacements are in the Reconstructed category. Deck overlays are in the Rehabilitation category.

Any new or reconstructed two lane bridge over railroad tracks shall be a minimum of 40’ wide.

For bridges longer than 200’, the traveled lanes plus 4’ on each side is an acceptable bridge width when considering new or reconstruction.

For new or reconstruction projects, the rail system shall meet NCHRP 350 Test Level 3 or an equivalent standard. For rehabilitation projects, all elements of the rail system can remain in place if the system meets or exceeds NCHRP 230 or an equivalent standard. If any part of the rail system does not meet or exceed NCHRP 230 or an equivalent standard, it will be upgraded to meet or exceed NCHRP 350 Test Level 3 or equivalent standard crash test criteria. For preventive maintenance projects, the existing railing system can remain.

Slope Protection repair, joint repair, painting, scour repair, abutment repair, pier repair, damaged railing repair, etc. are all examples of bridge preventive maintenance. For these types of preventive maintenance projects, the existing railing system can remain.

OTHER ROUTES

For county route traffic bridges that are State owned bridges that do not carry state route traffic, widths will be addressed on an individual basis.

For State owned bridges on county roads. i.e. county roads over the Interstate:

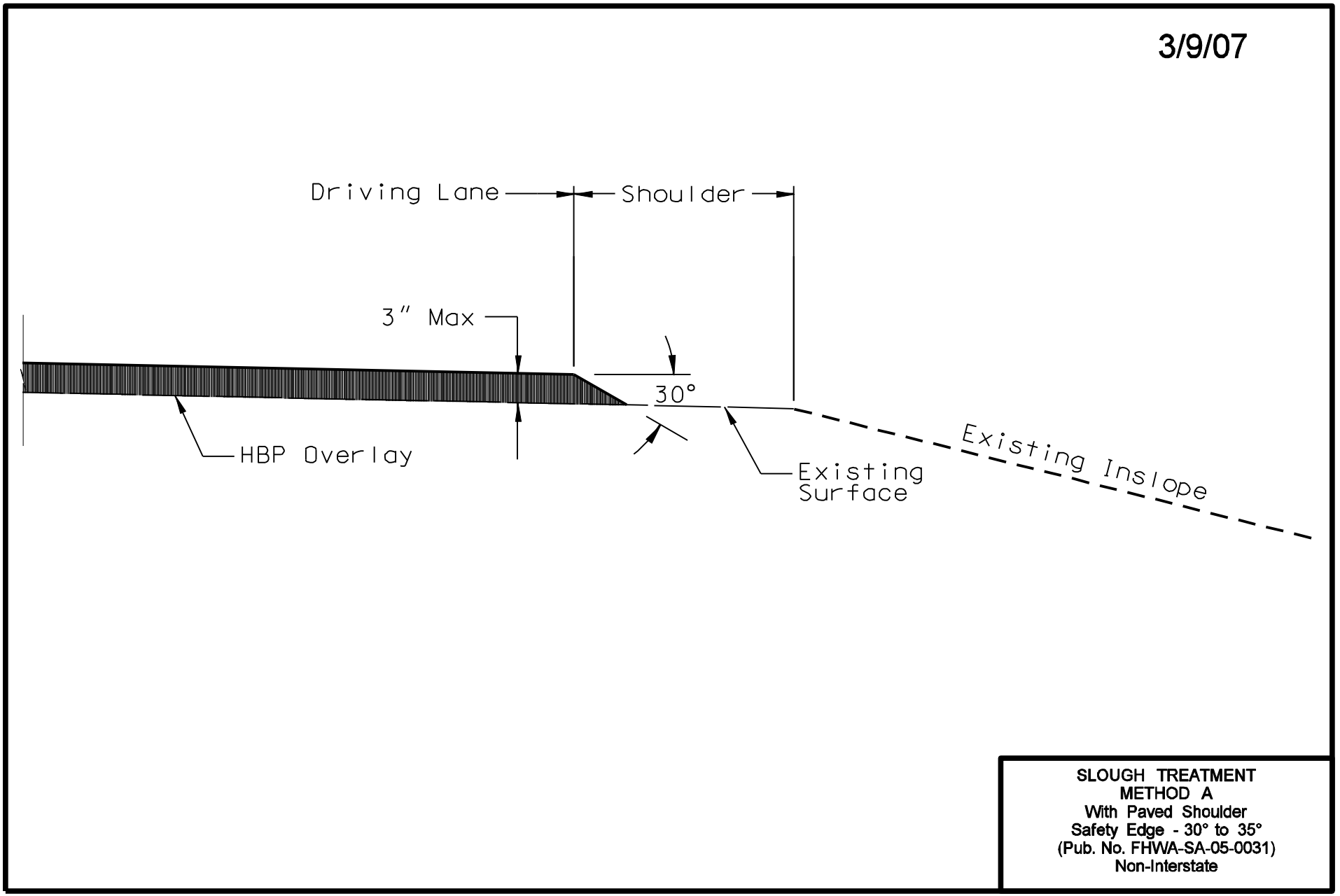
<= 750 ADT, existing width adequate, if no crash history

> 750 ADT, existing width adequate if no more than 6’ less than the width of the approach roadway, if no crash history.

For Preventive Maintenance projects existing bridge widths can remain.

Slope Protection repair, joint repair, painting, scour repair, abutment repair, pier repair, damaged railing repair, etc. are all examples of bridge preventive maintenance. For these types of preventive maintenance projects, the existing railing system can remain.

I-06.03.10 Department Shoulder/Slough Guidelines



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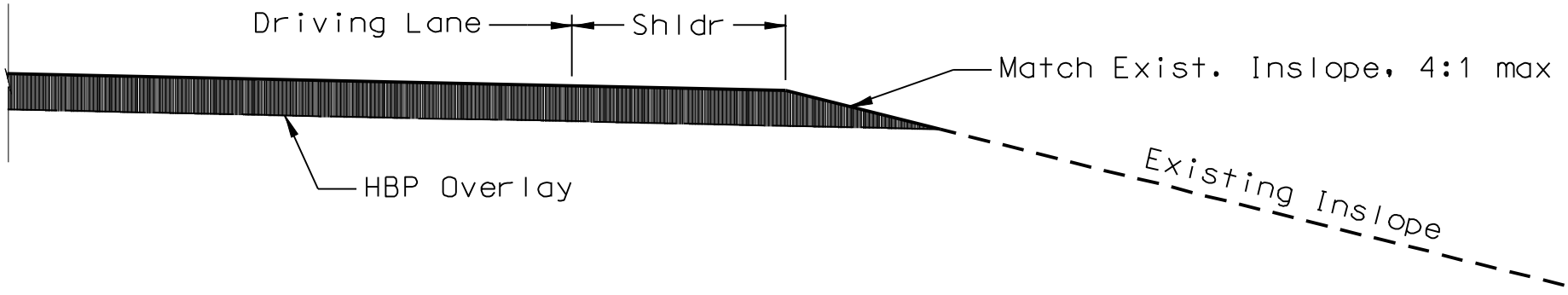
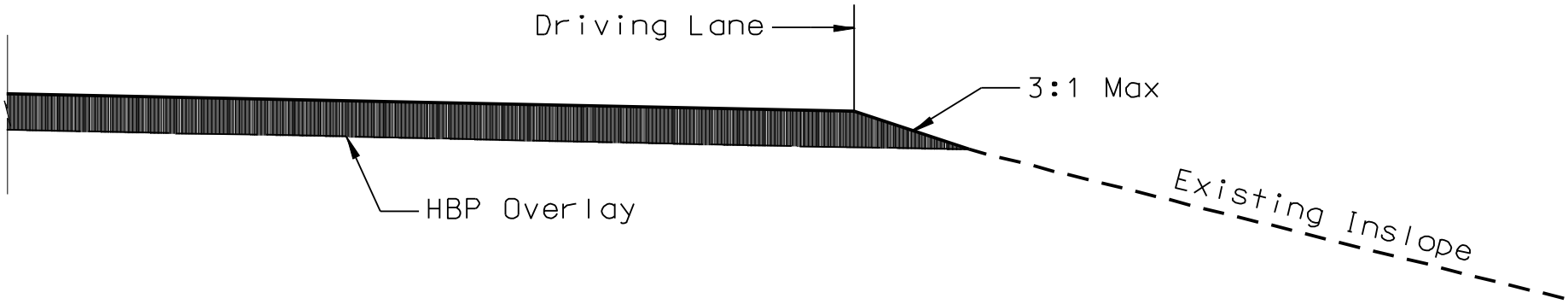


* This is the only Slough Treatment that will be applied to Interstate Overlays

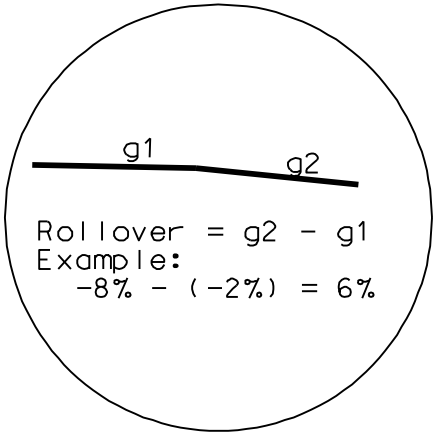
SLOUGH TREATMENT
METHOD B
With Paved Shoulder
Match Existing Inslope, 4:1 max
Non-Interstate & Interstate*

3/9/07

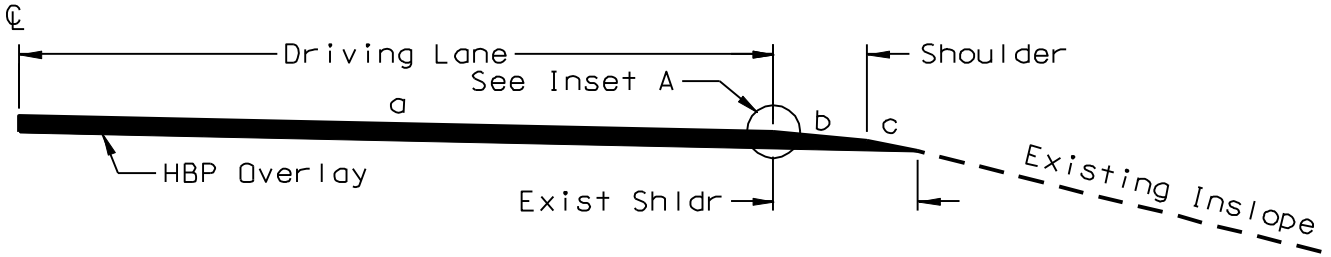


SLOUGH TREATMENT
METHOD C
No Paved Shoulder
Non-Interstate

3/9/07



Inset A



1. a = Driving lane cross-slope

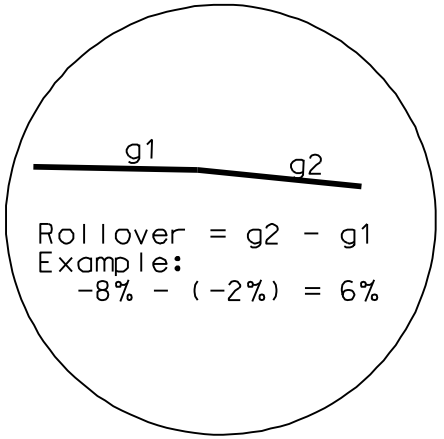
2. b = PM, MiR, SI: Non-Interstate: 8% max, with 6% max rollover
   MaR: 6% max, with 5% max rollover
   Interstate: 6% max, with 5% max rollover

3. If final shoulder < 2',
   then use driving lane cross-slope

4. c = Non-Interstate: Match Exist Inslope, 3:1 max
   Interstate: 4:1 max

SHOULDER TREATMENT
METHOD 1
PM, MiR, SI, MaR
Non-Interstate & Interstate

3/9/07



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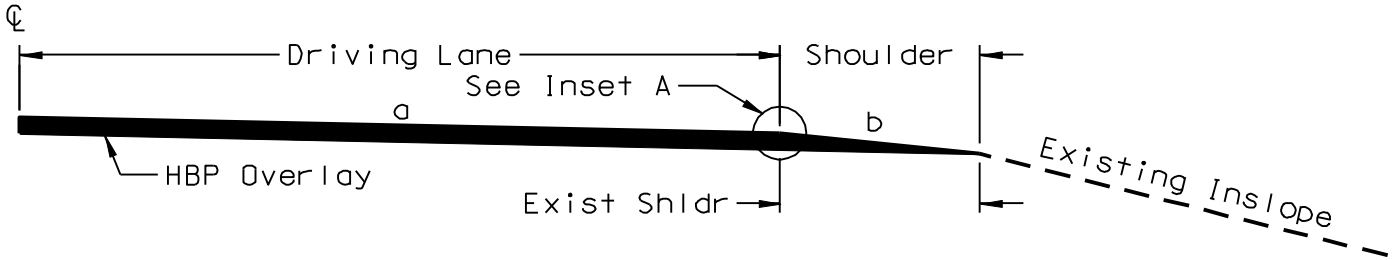
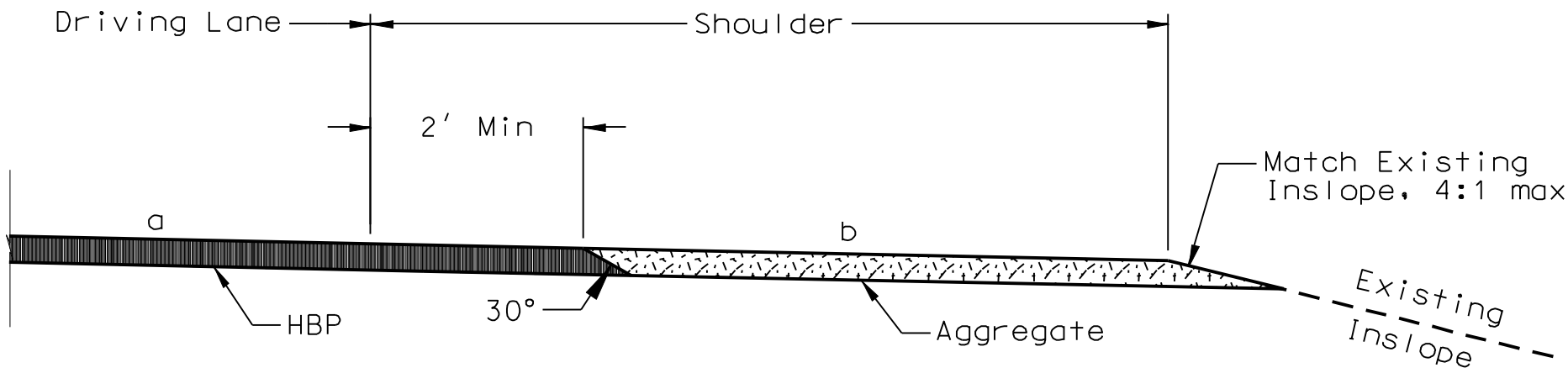


1. a = Driving lane cross-slope
2. b = Non-Interstate: 8% max, with 6% max rollover
   Interstate: 6% max, with 5% max rollover

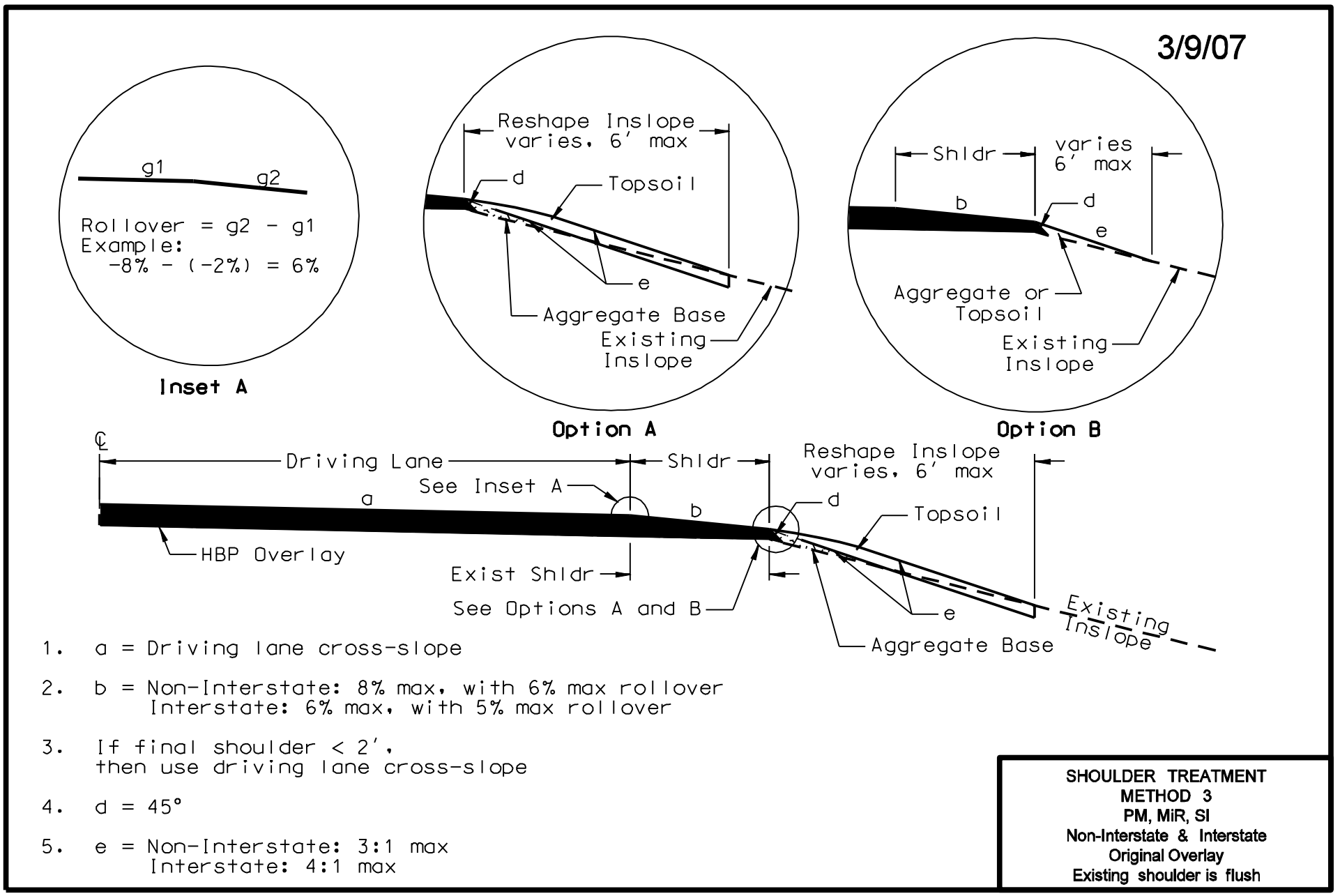
SHOULDER TREATMENT
METHOD 2a
PM, MiR, SI
Non-Interstate & Interstate

3/9/07



1. a = Driving lane cross-slope
2. b = PM, Mir, SI: Non-Interstate: 8% max, with 6% max rollover
   Mar: 6% max, with 5% max rollover

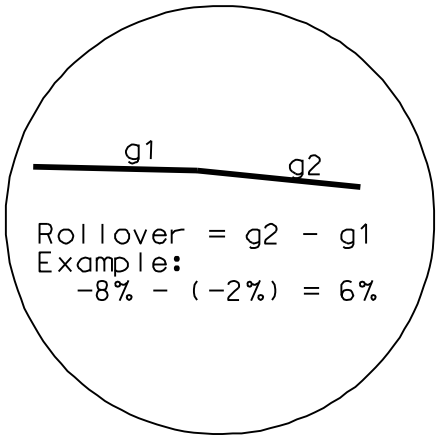
SHOULDER TREATMENT
METHOD 2b
SI, MaR
Aggregate Shoulders
Non-Interstate



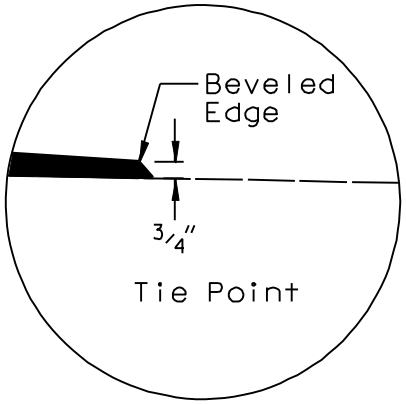
1. a = Driving lane cross-slope
2. b = Non-Interstate: 8% max, with 6% max rollover
   Interstate: 6% max, with 5% max rollover
3. If final shoulder < 2',
   then use driving lane cross-slope
4. d = 45°
5. e = Non-Interstate: 3:1 max
   Interstate: 4:1 max

SHOULDER TREATMENT
METHOD 3
PM, MiR, SI
Non-Interstate & Interstate
Original Overlay
Existing shoulder is flush

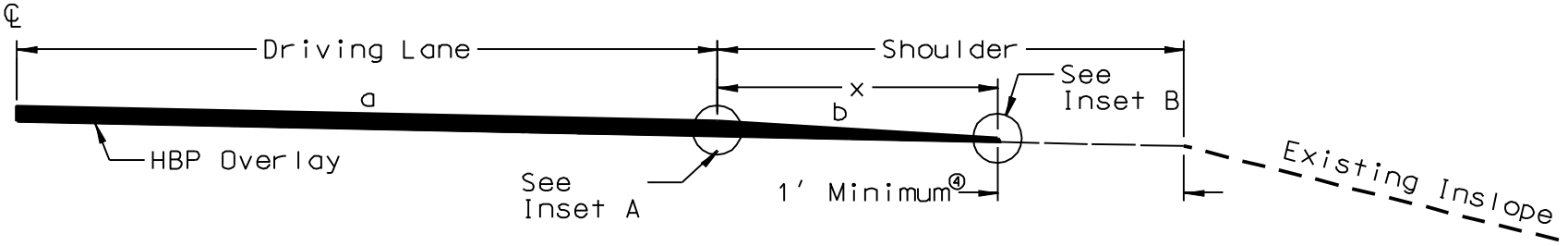
3/9/07



Inset A



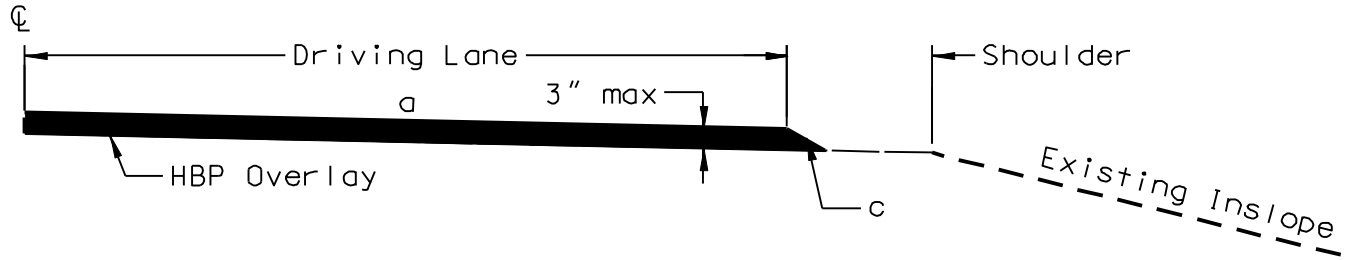
Inset B



1. a = Driving lane cross-slope
2. b = Proposed shoulder cross-slope
3. $x = x(ft) = \frac{\text{overlay thickness (ft) - (3/4" x 1'/12")}}{\text{"b" ('/') - slope of existing shoulder ('/')}}$
4. If the distance from the edge of the overlay to the pavement is less than 1' then consider a different Shoulder Treatment.

SHOULDER TREATMENT
METHOD 4
PM, MiR
Non-Interstate & Interstate

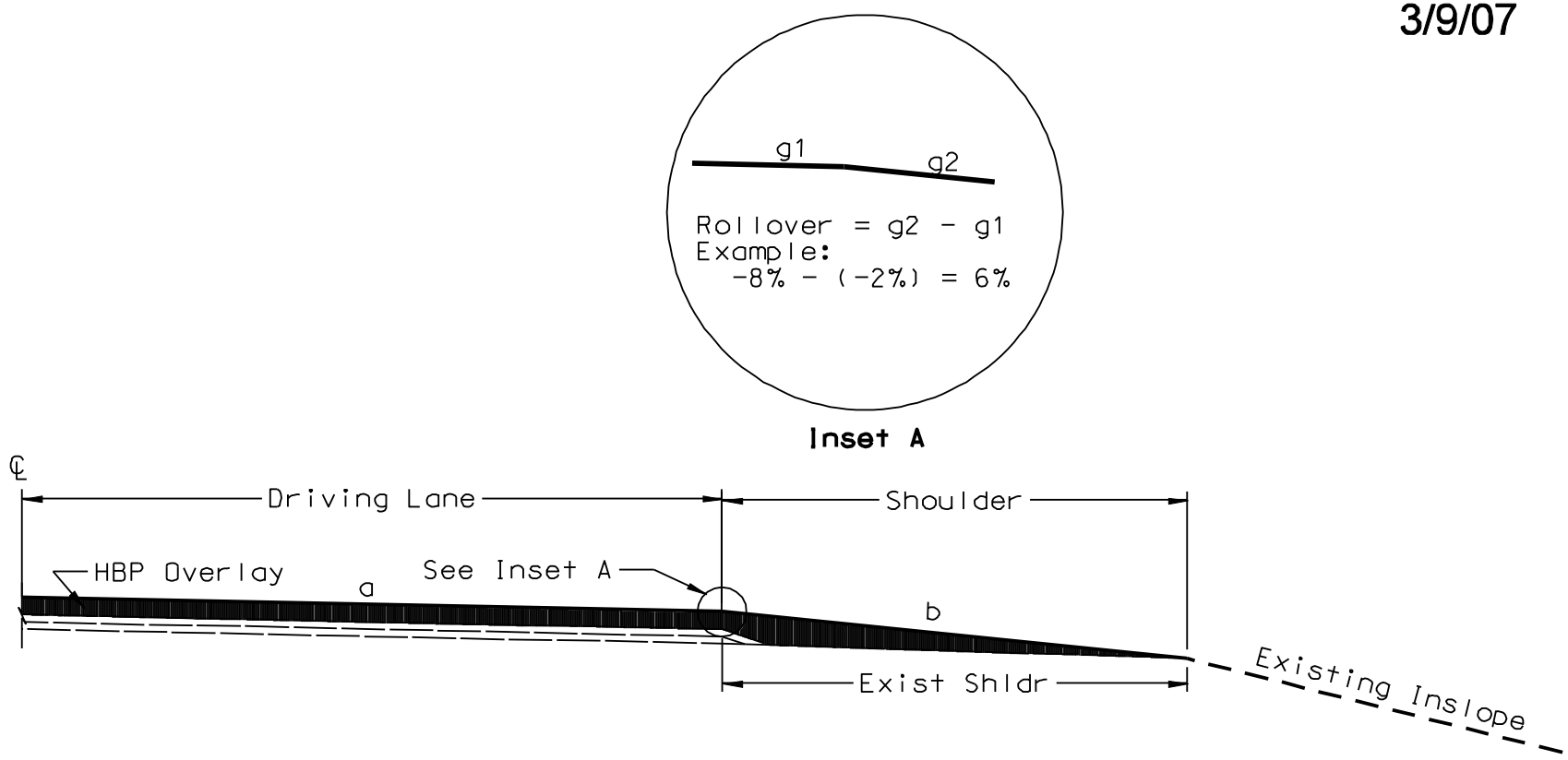
3/9/07



1. a = Driving lane cross-slope
2. c = 30° Safety Edge max, slough treatment

SHOULDER TREATMENT
METHOD 5
PM, MiR, SI
Non-Interstate

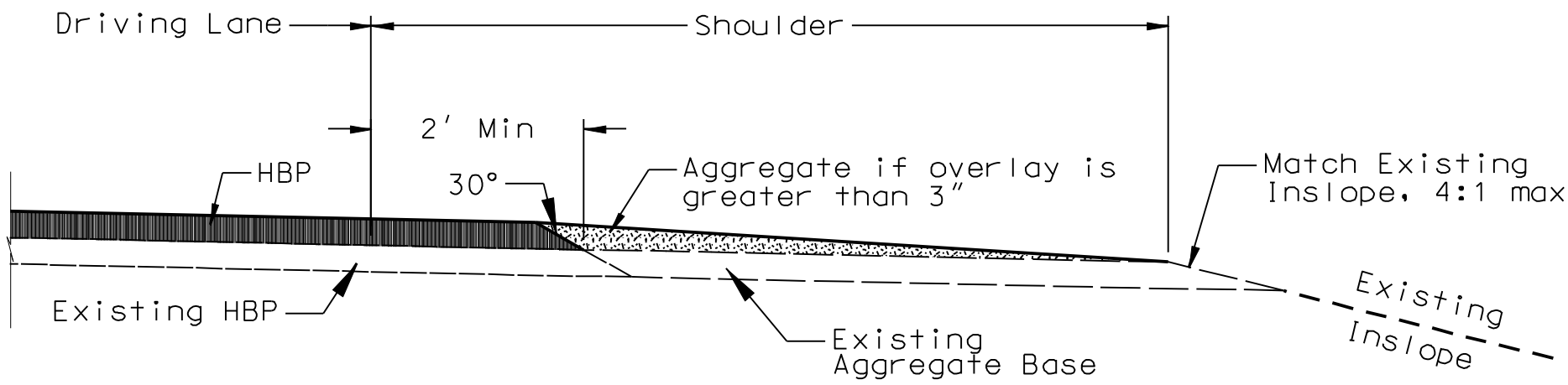
3/9/07



1. a = Driving lane cross-slope
2. b = PM, MiR, SI: 8% max, with 6% max rollover
   MaR: 6% max. with 5% max rollover

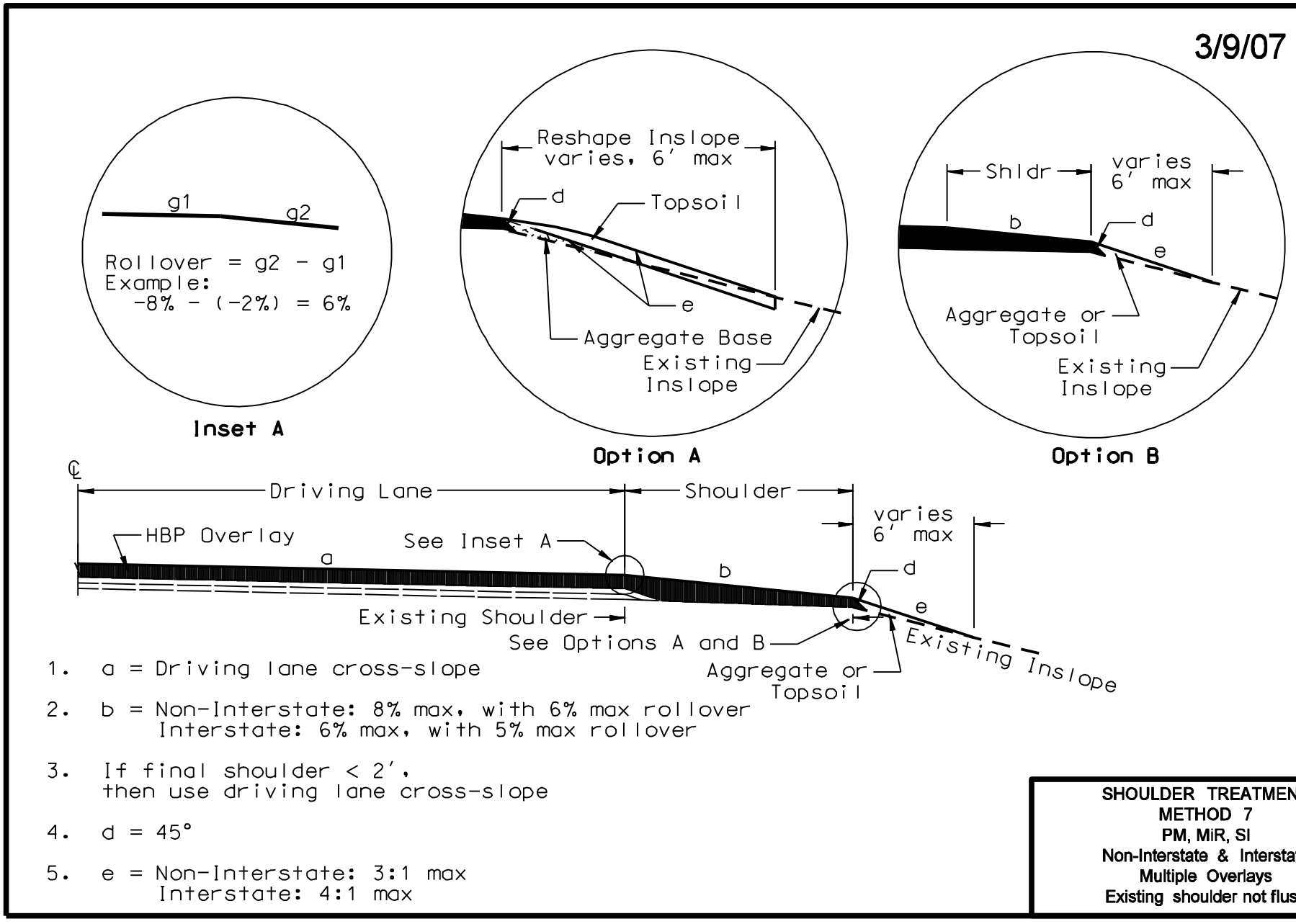
SHOULDER TREATMENT
METHOD 6a
PM, MiR, SI, MaR
Non-Interstate

3/9/07



1. a = Driving lane cross-slope

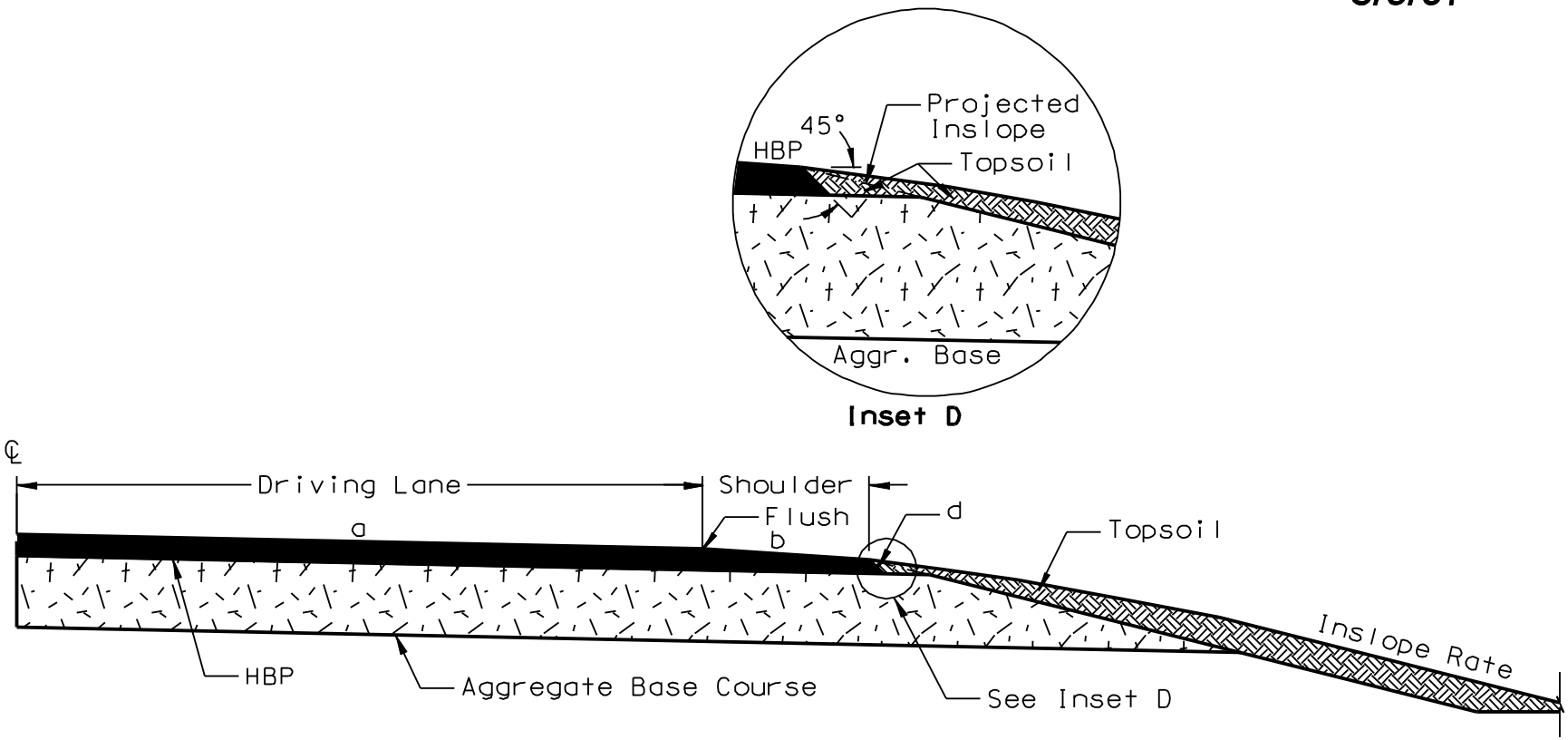
SHOULDER TREATMENT
METHOD 6b
PM, MiR, SI, MaR
Aggregate Shoulders
Non-Interstate



1. a = Driving lane cross-slope
2. b = Non-Interstate: 8% max, with 6% max rollover
   Interstate: 6% max, with 5% max rollover
3. If final shoulder < 2',
   then use driving lane cross-slope
4. d = 45°
5. e = Non-Interstate: 3:1 max
   Interstate: 4:1 max

SHOULDER TREATMENT
METHOD 7
PM, MiR, SI
Non-Interstate & Interstate
Multiple Overlays
Existing shoulder not flush

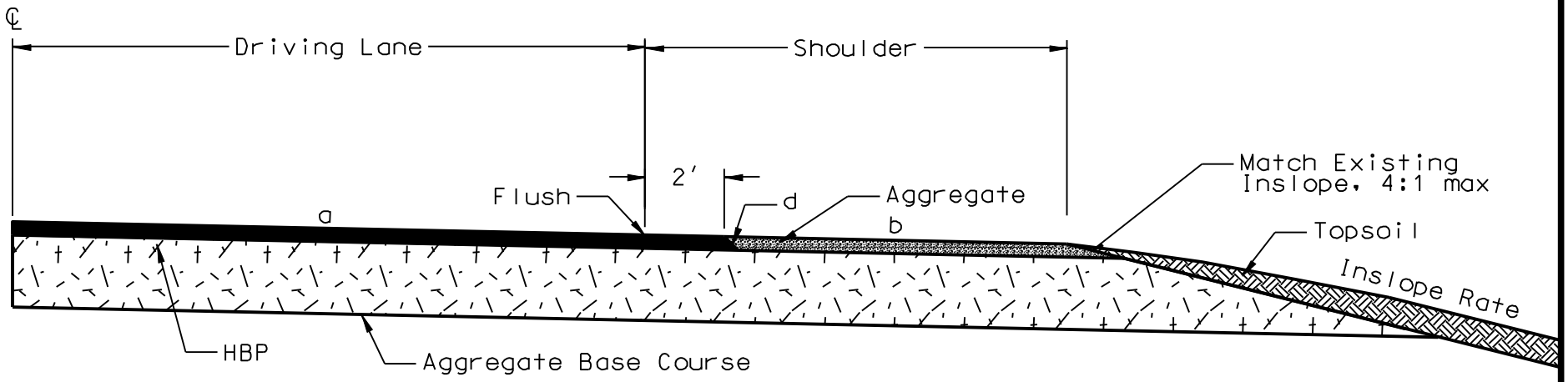
3/9/07



1. a = 1.5% to 2.5% Driving lane cross-slope
2. b = Recommend 3%, 6% max, with 5% max rollover
3. d = 45°

SHOULDER TREATMENT
METHOD 8a
NR
Non-Interstate

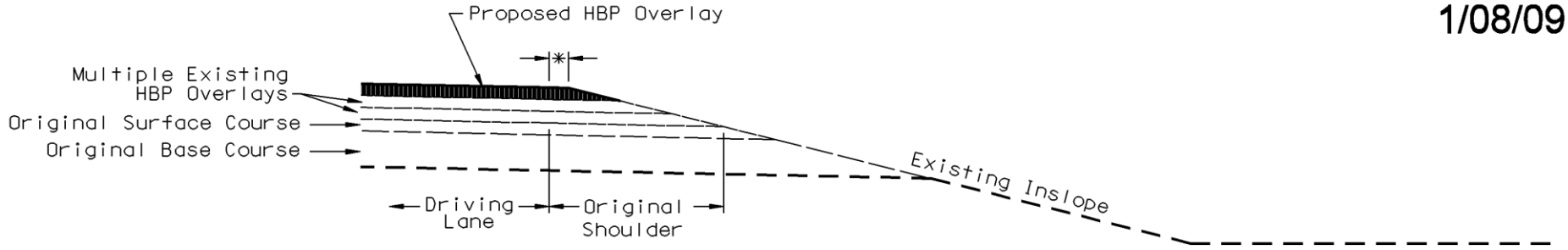
3/9/07



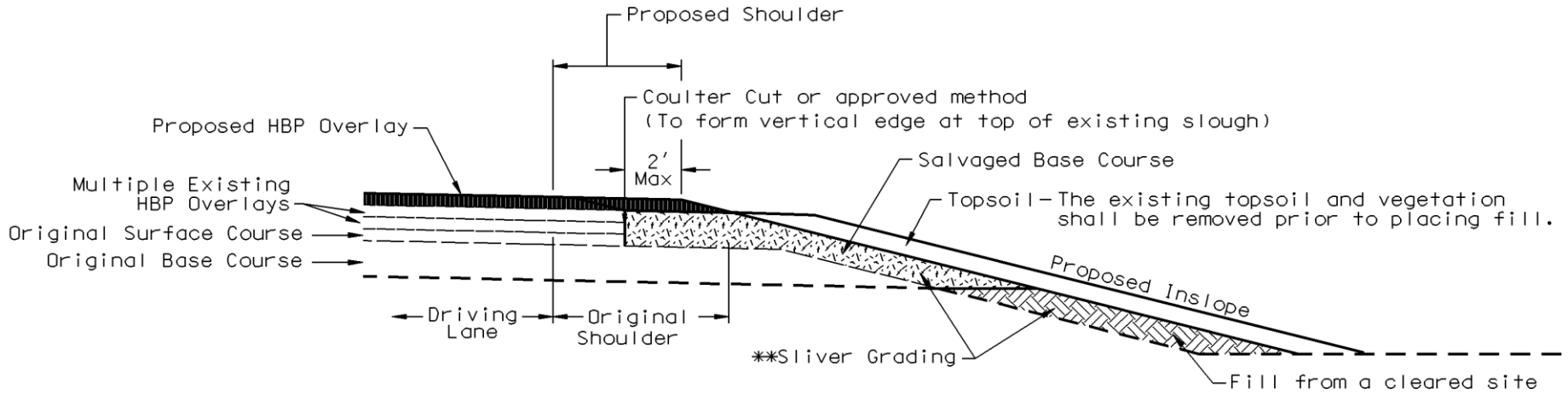
1. a = 1.5% to 2.5% Driving lane cross-slope
2. b = 4%-6%
3. d = 45°

SHOULDER TREATMENT
METHOD 8b
NR
Non-Interstate
Aggregate Shoulders

1/08/09



*Proposed HBP Overlay will decrease roadway width below the minimum roadway width requirements.



**Sliver Grading to meet minimum NDDOT guidelines (2' Max).

Sliver Grading is minor grading required to correct inslope or re-establish enough roadway width to meet NDDOT minimum guidelines, provided the original roadway width met or exceeded the proposed width.

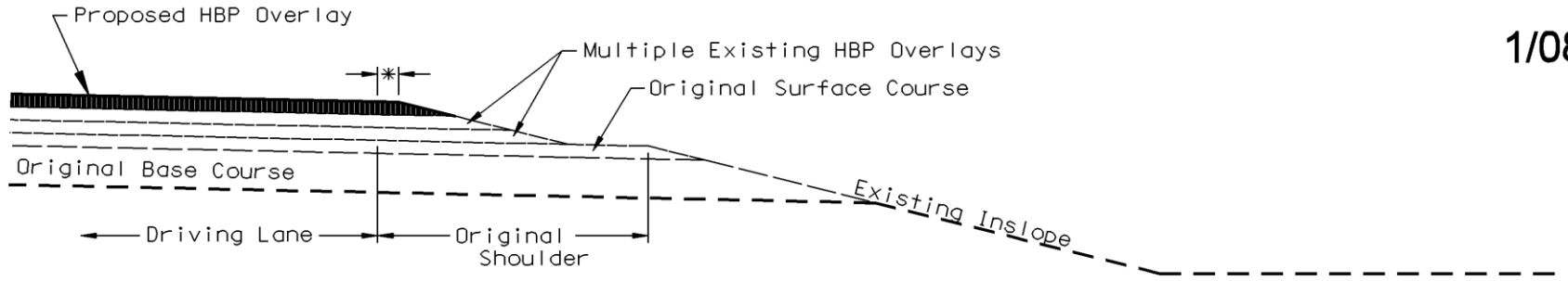
Sliver Grading is limited to 2' maximum of widening on each side of the roadway.

Sliver Grading is not grading to add roadway width beyond the original roadway.

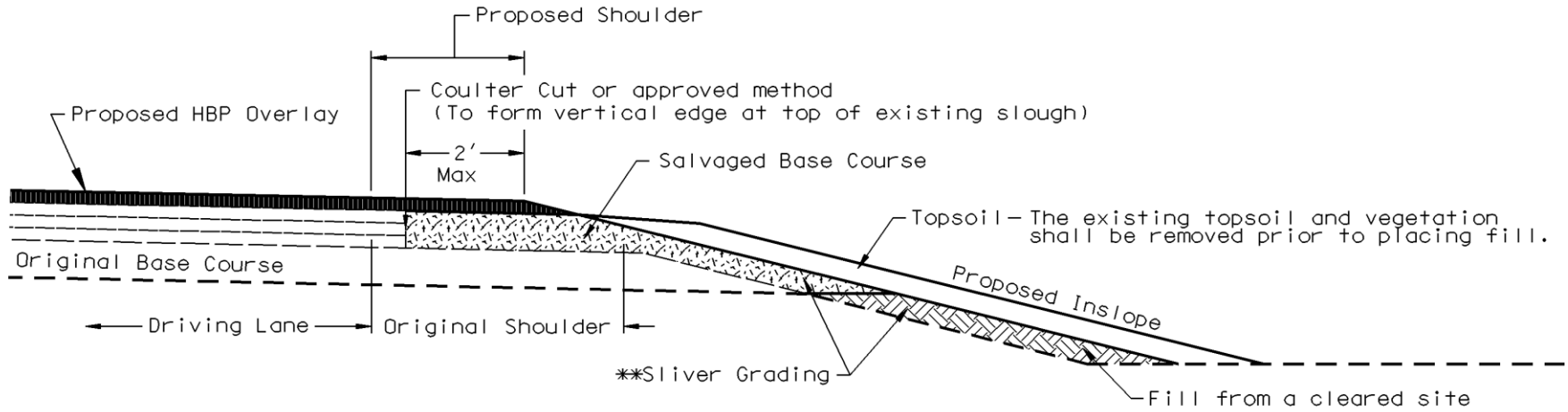
SLIVER GRADING
METHOD 9a

MiR
Non-Interstate & Interstate

1/08/09



*Proposed HBP Overlay will decrease roadway width below the minimum roadway width requirements.



**Sliver Grading to meet minimum NDDOT guidelines (2' Max).

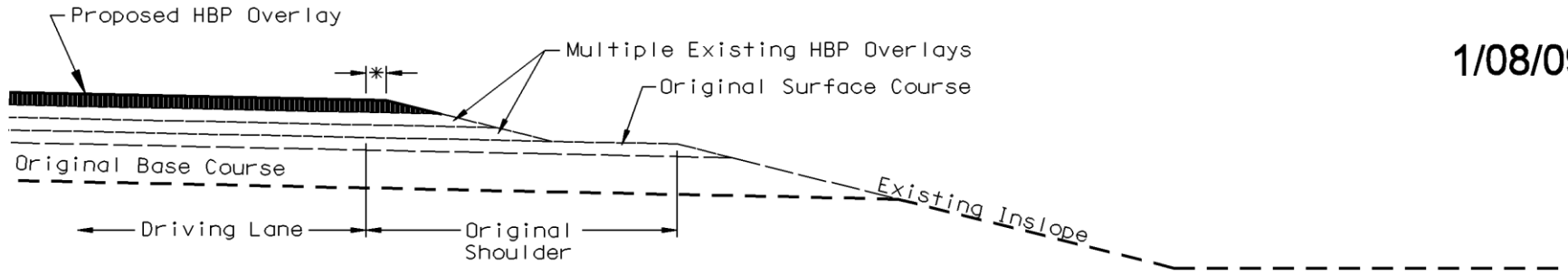
Sliver Grading is minor grading required to correct inslope or re-establish enough roadway width to meet NDDOT minimum guidelines, provided the original roadway width met or exceeded the proposed width.

Sliver Grading is limited to 2' maximum of widening on each side of the roadway.

Sliver Grading is not grading to add shoulder or lane width beyond the original roadway.

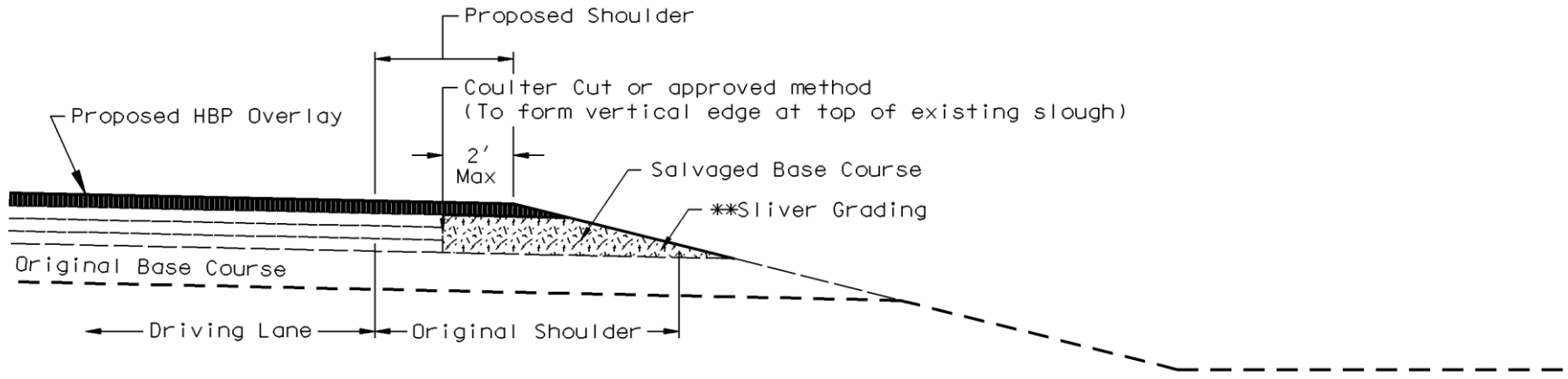
SLIVER GRADING
METHOD 9b

MiR
Non-Interstate & Interstate



1/08/09

*Proposed HBP Overlay will decrease roadway width below the minimum roadway width requirements.



**Sliver Grading to re-establish the original shoulder.

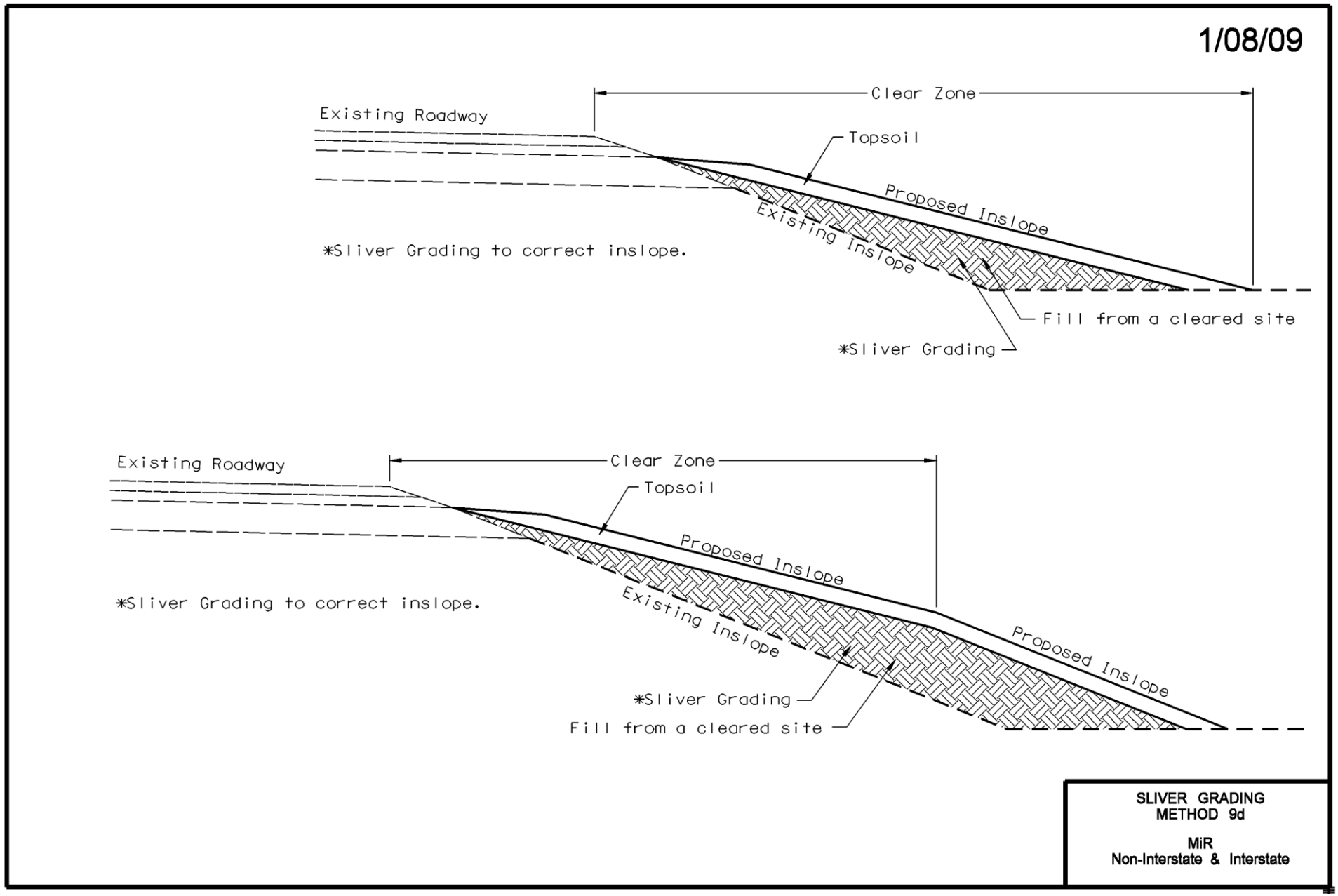
Sliver Grading is minor grading required to correct inslope or re-establish enough roadway width to meet NDDOT minimum guidelines, provided the original roadway width met or exceeded the proposed width.

Sliver Grading is limited to 2' maximum of widening on each side of the roadway.

Sliver Grading is not grading to add shoulder or lane width beyond the original roadway.

SLIVER GRADING
METHOD 9c

MiR
Non-Interstate & Interstate


1/08/09
Clear Zone
Existing Roadway
Topsoil
Proposed Inslope
Existing Inslope
*Sliver Grading to correct inslope.
Fill from a cleared site
*Sliver Grading
Existing Roadway
Clear Zone
Topsoil
Proposed Inslope
*Sliver Grading to correct inslope.
Existing Inslope
Proposed Inslope
*Sliver Grading
Fill from a cleared site
SLIVER GRADING
METHOD 9d
MiR
Non-Interstate & Interstate

I-06.04 Design Exceptions

Designers contemplating the need for the use of design values, on a specific project, which are not in compliance with the accepted *DESIGN GUIDELINES* listed earlier in this chapter, will document and obtain approval of a formal design exception. Exceptions to design standards are delegated from the Secretary of Transportation to the Division Administrator (DA). The DA may not delegate them further in the Division Office.

Design Exceptions will be submitted to FHWA for all interstate projects, for NHS projects > $5 million, and for other full involvement projects selected by mutual agreement between NDDOT and FHWA. The Design Exception will be a stand alone document, and will not be included in the Project Concept Report (PCR). Design exceptions that require FHWA will be attached to the PCR but not included within the PCR. Design Exceptions not requiring approval by FHWA are approved internally by the NDDOT as when PS&E approval is delegated to NDDOT via exemption, NDDOT must approve the design exception in the same manner as would have been done by FHWA. This applies on the NHS regardless of funding source, even if all funds are non-Federal aid.

Design exceptions are not required on Interstate projects utilizing a Major Rehabilitation strategy or less for horizontal or vertical alignments, widths of median, traveled way, and shoulders provided these features met standards when they were built and are not reduced by the project. The remaining design criteria, including traffic barriers, must meet current standards or undergo the design exception process. Where the type of work is reconstruction, current standards are to be applied throughout the project including bridges to remain in place.

Design Exceptions shall be written and presented in the format shown in the Design Exception Form found on the web at http://www.dot.nd.gov/manuals/design/designmanual/designmanual.htm under Design Manual Reference and Forms in the "Design Exception Form" table. Generally, the following design elements will require a formal design exception if the use of design values not in compliance with accepted values is contemplated:

- Design Speed
- Lane Width
- Shoulder Width
- Horizontal Alignment
- Vertical Alignment
- Grade
- Superelevation
- Cross Slopes (including edge taper to slough)
- Stopping sight Distance
- Bridge Width
- Bridge Structural Capacity (including static loading of bridge railings)
- Horizontal Clearance (not including clear zone)
- Vertical Clearance
- Guardrail
- Clearzone

A Design Exception must be written for each design element that does not meet standards. Multiple design elements cannot be combined in a Design Exception.

Supplemental items to consider when evaluating a design exception:

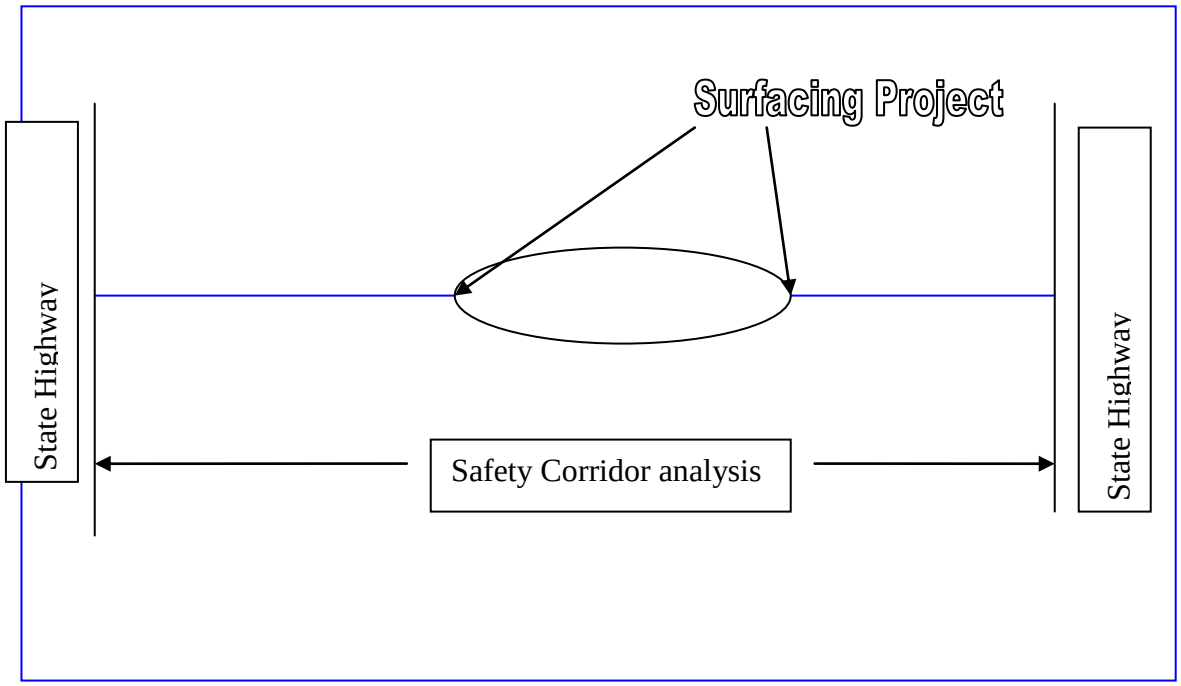
- Crash history to determine any history of operational problems.
- Functional classification of the roadway.
- Effect of the variance from the design standard on safety and operations.
- The degree of the variance from the standard.
- Compatibility with adjacent sections of roadway.
- Should not degrade the relative safety of the roadway.
- Amount and character of the traffic.
- Posted and actual speed on the route.
- Type of project contemplated.
- Cost of attaining full standards (including environmental impacts).
- Cost-effective means of mitigating the reduction in standard.
- Program of future projects, in particular, whether future improvements may more be economically correct the design feature at a later date.
- Engineering discretion

I-06.05 Statewide Safety Program

STATEWIDE SAFETY PROGRAM

ANALYSIS STRATEGIES

The Statewide Safety program will consist of four different types of analysis. Safety projects will be based on corridor improvements. A corridor is defined as the intersection of State Highway to State Highway as shown in the figure below.



1. Critical Rate Analysis

The NDDOT will review the entire state highway system on a yearly basis in an effort to identify the sections of roadway corridor that exhibit the highest crash rates. Those corridors of highways that exhibit a crash rate higher than the critical rate for their particular Highway Performance Classification System (HPCS) will be reviewed in greater detail to determine if there are cost effective measures that can be made or if engineering judgment determines that improvements should be made.

The Concept of "Critical Crash Rate" suggests that any sample or category of intersections or roadway corridors can be divided into three basic parts:

- Locations with a crash rate below the average will be eliminated from further review.
- Locations with a crash rate above the average, but below the critical rate are locations where there is a very high probability (90-95%) that the higher than average crash rate is due to the random nature of crashes.
- Locations with a crash rate above the critical rate will be reviewed because there is a high probability (90-95%) that conditions at the site are contributing to the higher crash rate

Critical crash rate is calculated: $R_c = R_a + K(R_a/m)^{1/2} – 0.5/m$

(Critical crash rate is based on MnDOT Methodologies)

R_c = Critical Crash Rate for:
Intersections: crashes per MEV
Corridors: crashes per MVM

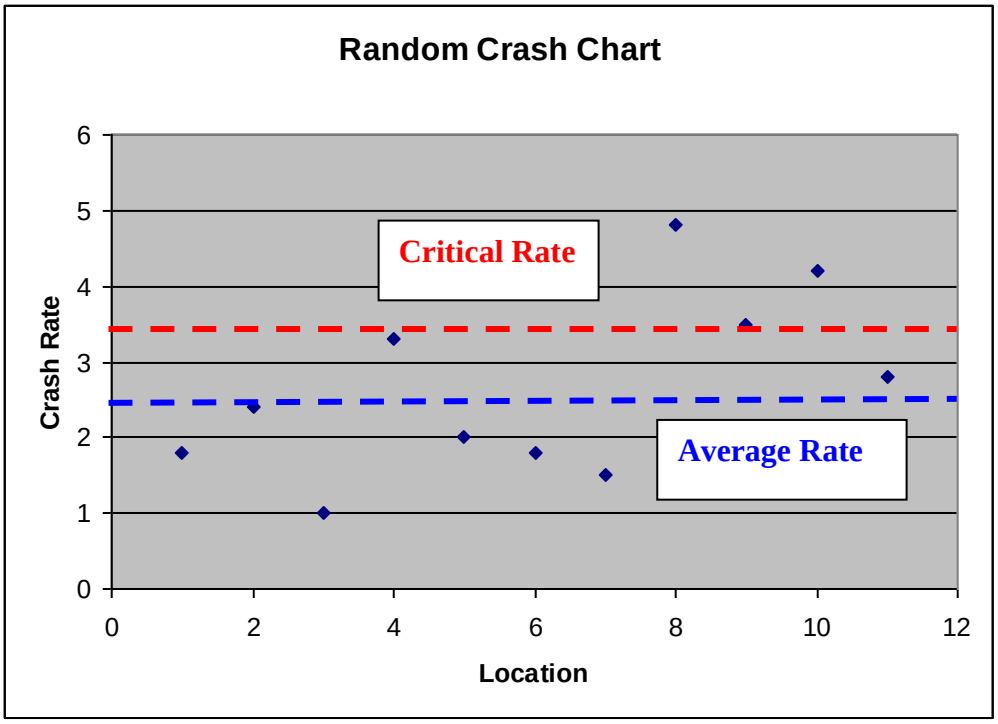
R_a = HPCS Average Crash Rate by intersection or HPCS type.

M = Vehicle Exposure During Study Period for:
Intersections: ADT ($365/10^6$)
Corridors: ADT ($365/10^6$) length

K = Constant based on Level of Confidence

Level of Confidence	0.995	0.950	0.900
K	2.576	1.645	1.282

Sample Graph



2. High Crash Analysis

The High Crash Analysis will be done on a yearly basis for the entire state highway system. Those intersections or sections of roadway that are identified in this report will be reviewed in greater detail to determine if there are cost effective measures that can be made or if engineering judgment determines that improvements should be made.

3. Project level Analysis

On Structural Improvement, major rehabilitation and new construction projects, each project will be reviewed to determine if there are cost effective measures that can be made or if engineering judgment determines that improvements should be made.

4. Strategic Highway Safety Plan (SHSP)

On Structural Improvement, major rehabilitation and new construction projects, each project will be reviewed to determine if there are cost effective measures that can be made that are related to the emphasis areas identified in the SHSP.

COUNTER MEASURES

Appendix A provides examples of how identified “Areas of Concerns” and “Alternative Safety Measures” can be developed. The Alternative Safety Measures would be those measures that would be evaluated for cost effective improvements.

IMPLEMENTATION MEASURES

Cost effective measures will be implemented one of two ways.

1. If the improvement is an improvement that should be made throughout the corridor, a safety project will be scheduled and included in the STIP. The goal would be to make the necessary improvements within three years of the highway improvement project or when safety funds are available.

2. If the improvement is specific to a feature that is contained within the limits of the project. The cost effective measure will be included with that project.

   Example: If the superelevation on a curve is identified as a hazard, a cost effective measure as identified in Appendix A will be used to correct the hazard during construction of the project.

COUNTER MEASURES

Accident Type	Possible Cause	Possible Study	Possible Safety Enhancement
Run-Off-Road	Slippery pavement/ ponded water	Check skid resistance Check for adequate drainage Perform spot speed study	Reduce speed limit if justified by spot speed study Provide "SLIPPERY WHEN WET" signs Provide adequate drainage Groove existing pavement Overlay existing pavement
	Roadway design inadequate for traffic conditions	Check roadside shoulders and road maintenance Check superelevations Perform ball-bank study	Install/improve traffic barriers Close curb lane Flatten slopes/ditches Relocate islands Improve alignment/grade Provide proper superelevations Provide escape ramp Widen lanes/shoulders
	Poor delineation	Review pavement markings Review signs and placement	Install roadside delineators Install advance warning signs Improve/install pavement markings
	Poor visibility	Check roadway illumination	Increase sign size Improve roadway lighting
	Improper channelization	Review channelization	Improve channelization
Collision at driveways	Left-turning vehicles	Perform turning counts	Install median divider Install two-way left-turn lanes
	Improperly located driveway	Review driveway placement	Regulate minimum spacing of driveways Regulate minimum corner clearance Move driveway to side street Install curbing to define driveway location Consolidate adjacent driveways
	Right-turning vehicles	Perform turning counts Review Parking Check driveway and lane width Check curb radii	Restrict parking near driveways Increase the width of the driveway Increase curb radii Provide right-turn lanes Widen through lanes
	Large volume of through	Perform volume count	Move driveway to side street

Accident Type	Possible Cause	Possible Study	Possible Safety Enhancement
	traffic	for thru traffic	Construct a local service road Reroute through traffic
	Large volume of driveway traffic	Perform volume count for driveway traffic Perform gap study	Signalize driveway Provide acceleration and deceleration lanes Channelize driveway
	Restricted sight distance	Field observation for sight obstructions Review parking Check roadway illumination Perform spot speed study	Restrict parking near driveways Reduce speed limit if justified by spot speed study Install/improve street lighting Remove sight obstruction
Sideswipe or head-on	Inadequate road design and/or maintenance	Review lane width Check alignment Perform no passing study Check road surface for proper maintenance	Perform necessary road surface repairs Sign and mark unsafe passing areas Provide roadside delineators Improve alignment/grade Provide wider lanes Provide passing lanes
	Inadequate shoulders	Review road shoulders	Improve shoulders
	Excessive vehicle speed	Perform spot speed study	Reduce speed limit if justified by spot speed study Install median devices
	Inadequate pavement markings	Review pavement markings	Install/improve centerlines, lane lines, and edgelines Install reflectorized markers Install centerline rumble strips
	Inadequate channelization	Review channelization	Install/improve channelization Install acceleration and deceleration lanes Provide turning bays
	Inadequate signing	Review signing and placement	Provide advance direction and warning signs Add illuminated name signs
Pedestrian/ bicycle	Limited sight distance	Check sight distance	Remove sight obstruction Install/improve pedestrian crossing signs and markings Reroute pedestrian paths
	Inadequate protection	Check existing	Add pedestrian refuge islands

Accident Type	Possible Cause	Possible Study	Possible Safety Enhancement
		protection	
	Inadequate signal/signs	Review signal/signs	Install/upgrade signals/signs
	Inadequate signal phasing	Review signal phasing	Change timing of pedestrian phase Add pedestrian "Walk" phase
	Inadequate pavement markings	Review pavement markings	Supplement markings with signing Upgrade pavement markings
	Inadequate lighting	Check roadway illumination	Improve lighting
	Driver has inadequate warning of frequent mid-block crossing	Review existing parking Perform spot speed study	Prohibit parking Install warning signs Reduce speed limit if justified by spot speed study Install pedestrian barriers
	Lack of crossing opportunity	Perform gap study	Install traffic/pedestrian signals Install pedestrian crosswalk and signs
	Excessive vehicle speed	Perform spot speed study	Reduce speed limits Install proper warning signs
	Pedestrians/bicycles on roadways	Review existence of sidewalks	Eliminate roadside obstructions Install curb ramps with detectable warning panels Install sidewalks Install bike lanes/paths
	Long distance to nearest crosswalk	Check distance and travel time to nearest crosswalk	Install pedestrian crosswalk Install pedestrian actuated signals
	Sidewalk too close to traveled way	Review existing sidewalks	Move sidewalk laterally away from roadway
	School crossing area	Check pedestrian crossing time and available gaps Check school's safe route to and from school program Check school's student awareness program	Establish save route and awareness program Use school crossing guards Install crosswalks and traffic signal
Bridges	Alignment	Check alignment	Install advance warning sings

Accident Type	Possible Cause	Possible Study	Possible Safety Enhancement
			Improve delineation/markings Realign bridge/roadway
	Narrow roadway	Review lane width Review signing	Improve delineation/markings Install signing/signals Widen structure
	Visibility	Field observation for site obstruction	Improve delineation/markings Install advance warning sings Remove obstruction
	Vertical clearance	Check clearance	Improve delineation/markings Install advance warning sings Provide height restrictor/warning device Rebuild structure/adjust roadway grade
	Slippery surface (wet/icy)	Check skid resistance Check for adequate drainage	Provide special signing Provide adequate drainage Improve skid resistance Resurface deck
	Rough surface		Rehabilitate joints Resurface deck Regrade approaches
	Inadequate barrier system	Field observation and checks against established barrier standards	Improve delineation/markings Remove hazardous curb Upgrade bridge rail Upgrade bridge approach rail connections Upgrade approach rail/terminals
Collisions at railroad crossings	Restricted sight distance	Review sight distance	Install advance warning signs Remove sight obstructions Install train actuated signals Install gates Reduce grades
	Poor visibility	Check roadway illumination Review signing	Increase size of signs Improve roadway lighting
	Inadequate pavement marking	Review pavement markings	Install advance markings to supplement signs Install stop bars

Accident Type	Possible Cause	Possible Study	Possible Safety Enhancement
			Install/improve pavement markings
	Rough crossing surface	Check crossing surface	Improve crossing surface
	Sharp crossing angle	Check crossing angle	Rebuild crossing with proper angle
	Improper pre-emption timing of traffic signals, railroad signals, or gates	Review traffic signal timing Review railroad signal and gate timing	Retime traffic signals Retime railroad signals and gates
Nighttime	Poor visibility or lighting	Check roadway illumination	Install/improve warning sings Install/improve delineation/markings Install/improve street lighting
	Poor sign quality	Review signing	Upgrade signing Provide illuminated reflectorized signs
	Inadequate channelization of delineation	Review channelization/delination	Install pavement markings Improve channelization/delination
Wet pavement	Slippery pavement	Check skid resistance Check for adequate drainage Perform spot speed study	Provide “SLIPPERY WHEN WET” signs Reduce speed limit if justified by spot speed study Provide adequate drainage Groove existing pavement Overlay existing pavement
	Inadequate pavement marking	Review pavement markings	Install raised/reflectorized pavement markings
Rear-end collisions at unsignalized intersections	Pedestrian crossing	Review pedestrian signing and crosswalk marking	Install/improve signing or marking for pedestrian crosswalks Relocate crosswalk
	Driver not aware of intersection	Review signing	Install/improve warning signs
	Slippery surface	Check skid resistance Check for adequate drainage Perform spot speed study	Provide “SLIPPERY WHEN WET” signs Reduce speed limit if justified by spot speed study Groove existing pavement Overlay existing pavement
	Large number of turning	Perform turning counts	Prohibit turns

Accident Type	Possible Cause	Possible Study	Possible Safety Enhancement
	vehicles	Perform volume count for thru traffic	Increase curb radii Create left-of-right-turn lanes
Collisions with parked cars or cars being parked	Inadequate road design	Check lane width Review parking angle	Change from angle to parallel parking Prohibit parking Widen lanes/shoulders
	Large parking turnover	Perform paring turnover study	Prohibit parking Change from angle to parallel parking Create one-way streets Create off-street parking
	Improper pavement markings	Review pavement markings	Correct pavement markings
	Illegal parking	Law observance study	Enforcement
Overturn	Roadside features	Determine sideslope Investigate recovery zone	Provide traversable culvert end treatments Extend culverts Install/improve traffic barriers Flatten slopes and ditches Relocate drainage facilities
	Inadequate shoulder	Determine shoulder dimensions and composition Check for shoulder drop offs	Upgrade shoulder surface Remove curbing obstruction Widen lane/shoulder
	Pavement feature	Check for potholes Check for water ponding	Eliminate edge drop off Improve superelevation/crown
Fixed object	Obstruction in or too close to roadway	Field observation to locate obstruction	Delineation/reflectorize safety hardware Remove/relocate obstacles Install breakaway features to light poles, signposts, etc. Protect objects with guardrail Install crash cushions
	Inadequate lighting	Check illumination	Improve roadway lighting
	Inadequate pavement marking	Review pavement markings	Install reflectorized pavement lines/raised markers

Accident Type	Possible Cause	Possible Study	Possible Safety Enhancement
	Inadequate signs, delineators and guardrail	Review signs, delineators and guardrails	Install reflectorized paint, and/or reflectors on the fixed object Add special signing Upgrade barrier system
	Inadequate road design	Check roadside shoulders and maintenance Check superelevation Perform ball-bank study	Install Warning signs/delineators Improve alignment/grade Provide proper superelevation Provide wider lanes
	Slippery surface	Check skid resistance Check for adequate drainage	Reduce speed limit if justified by spot speed study Provide adequate drainage
Right-angle collisions at unsignalized intersections	Restricted sight distance	Filed observations for sight obstructions Check roadway illumination Perform spot speed study	Install warning signs Install stop signs Install yield signs Restrict parking near corners Reduce speed limit if justified by spot speed study Remove sign obstructions Install signals Install/improve street lighting Channelize intersection
	Large total intersection volume	Volume count on all approaches	Install signals
	High approach speed	Perform spot speed study	Reduce speed limit if justified by spot speed study Install rumble strips
Right-angle collisions at signalized intersections	Poor visibility of signals	Review existing signals and placement Field observation for sight obstructions Perform spot speed study	Install advanced warning devices Install visors Install back plats Reduce speed limit if justified by spot speed study Remove sight obstructions Add additional signal heads Install 12-inch signal lenses Improve location of signal heads Install overhead signals

Accident Type	Possible Cause	Possible Study	Possible Safety Enhancement
	Inadequate signal timing	Volume count on all approaches Review signal timing	Adjust amber phase Provide all-red clearance phases Add multi-dial controller Install signal actuation Retime signals Provide progression through a set of signalized intersections